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Origami that folds itself

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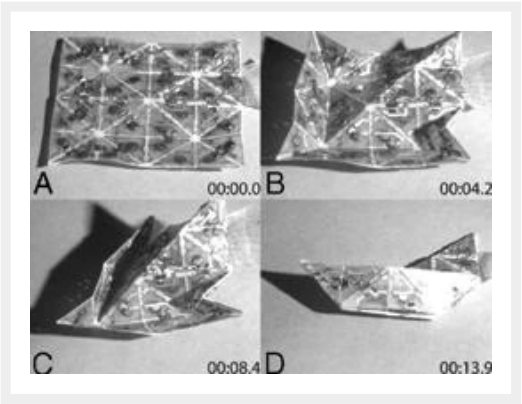
Programmable sheet puckers up spontaneously into an aeroplane or a boat.



An experimental 'boat' self-folds as actuators receive current and magnetic closures engage.
Credit: Hawke et al./PNAS

Making folded aeroplanes and boats is an activity more usually associated with bored schoolchildren than with cutting-edge engineering. But what distinguishes the products

f rudimentary origami made by Robert Wood and his team is that they fold themselves.

Wood and colleagues at Harvard University and the Massachusetts Institute of Technology in Cambridge, Massachusetts, have equipped a thin sheet with programmable joints that flex in response to electrical warming[1].

The joints sit at flexible creases linking stiff triangular panels in the sheet, and folding instructions delivered electronically to the structure can collapse the 4-centimetre-square sheet into any of its possible folded shapes: in this case, the familiar aeroplane and boat.

The engineered sheet is effectively a shape-shifting robot — or, looked at another way, a kind of protean 'programmable matter'. Such a material might find a wide variety of uses, ranging from radio antennas and solar cells that can open up from a compact state (on satellites, for example) to devices that can move, swim, grip or manipulate other objects.

"This is certainly original work, which succeeds in what it sets out to do," says engineer Simon Guest of the University of Cambridge, UK, a specialist in folding structures.

Naturally creased

'Deployable structures' that fold and unfold from creased sheets in well-defined ways are well known in nature. Some leaves open up in this manner after being packed in a bud, and so do insect wings.

Such natural origami has inspired engineers and designers seeking ways to fold up sheets and films so that they can be packaged and unfurled efficiently. Examples include photovoltaic panels or solar sails on spacecraft that are folded away for launch and then deployed in space.

Those efforts have focused on unique folding patterns. Wood and colleagues have now combined deployable structures with the idea of 'programmable matter', developed independently by chemists interested in molecular self-assembly[2] and by robotics engineers working on 'self-reconfiguring' robots that can adapt their shape to different tasks and environments[3].

This combination involves two key elements. First, Wood's team uses a computer algorithm to figure out in principle how a sheet with a prescribed set of creases can be folded into a given three-dimensional shape. Then they put theory into practice using hinged 'actuators' that open and close on command.

These hinges are made of a 'smart' metal alloy of nickel and titanium called Nitinol, which can 'remember', returning to an initial shape after being warmed and then bent.

One-way switch

For their current prototype, the researchers used hinges that will switch only one way — fully open or fully closed — when warmed by flexible electrical wiring on the sheet. The hinges must be bent back by hand. But Wood and colleagues say that they have also made two-way hinges that will both open and close automatically.

The hinges are stapled into a sheet less than 0.5 millimetres thick, made from triangular panels of stiff fibreglass joined along their edges by flexible silicone rubber. In the middle of each panel sits a magnet, which holds them securely but not irreversibly together when they are folded face to face.

To enable a given sheet to fold into any of its allowed configurations without requiring computer control of the hinge-heating process, the team intends to develop removable 'stickers' containing the circuitry specific to a particular folded shape.

Stuck on top of the sheet, these stickers will fold the sheet in the desired way at the flick of a switch.

The researchers say that their reconfigurable sheets could be made larger or smaller. They might be used to make a measuring cup that could alter its capacity, or a shelving system that adapts to fit the space available.

Tine De Ruysser, a UK-based designer who uses folding patterns in textiles, says, "I am really impressed by this work." She adds: "This material would have great possibilities within the world of textiles, art and design — I'd like to get my hands on it!"

Guest says that subsequent work will need to address issues such as how fast the folding happens once the system is activated, and whether all structures that could theoretically be accessed from a particular configuration of panels in a sheet really can be accessed.

He also questions how strong the folded structures will be. "I'm happy that an antenna might be possible, but not a wrench," he says. "It seems unlikely that the current scheme could ever produce structures where strength is critical."

That, however, might become possible by adding the option of forging stronger links between the folded panels once they are in position.

References

1. Hawkes, E. et al. *Proc. Natl Acad. Sci. USA* advance online publication doi:10.1073/pnas.0914069107 (2010).

2. Lehn, J.-M. *Supramolecular Chemistry: Concepts and Perspectives* (Wiley-VCH, Weinheim, 1995).

3. Yim, M. et al. *IEEE Robot. Autom. Mag.* **14(1),** 43-52 (2007).

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